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厦门大学

硕 士 学 位 论 文

南海春季和夏季浮游植物类群组成的研究

Studies on Phytoplankton Community Structure during Spring and Summer in South China Sea

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摘　　要

本论文通过 2010 年春季和 2011 年夏季对南海进行大面调查，利用反相高效液相色谱法对浮游植物特征光合色素进行分析，结合 CHEMTAX 化学分类软件估算浮游植物各类群对总生物量（Chl *a*）的贡献，研究了南海浮游植物现存生物量及群落结构的时空变化，探讨了中尺度过程（上升流、涡旋）对浮游植物生物量和群落结构的影响，取得如下研究结果：

南海浮游植物光合色素和类群组成的空间变化特征：春季平均水柱积分（至 150 m）的总 Chl *a* 浓度在近岸、陆架、陆坡和海盆分别为 480.45±274.77、261.34±89.55、204.41±47.20 和 180.73±41.56 ng/L。夏季平均水柱积分（至 150 m）的总 Chl *a* 浓度在近岸、陆架、陆坡和海盆分别为 339.41±124.60、111.48±64.03、56.42±22.54 和 82.69±25.83 ng/L。主要特征光合色素浓度存在区域差异，春季，近岸为岩藻黄素、玉米黄素和叶绿素 *b*，陆架为叶绿素 *b*、二乙烯基叶绿素 *a* 和 19’-己酰基氧化岩藻黄素，而陆坡和海盆为二乙烯基叶绿素 *a*、19’-己酰基氧化岩藻黄素和玉米黄素；夏季，近岸为岩藻黄素、玉米黄素和叶绿素 *b*；而陆架、陆坡和海盆的主要特征光合色素均为玉米黄素、二乙烯基叶绿素 *a* 和 19’-己酰基氧化岩藻黄素。CHEMTAX 计算表明，春季近岸以聚球藻和硅藻为优势类群；陆架以定鞭金藻 4 型、青绿藻和聚球藻为优势类群；陆坡和海盆区以定鞭金藻 4 型、聚球藻和原绿球藻为优势类群。夏季近岸以聚球藻和硅藻为优势类群；陆架、陆坡和海盆以定鞭金藻 4 型、聚球藻和原绿球藻为优势类群。主要特征光合色素与环境因子的相关关系表现为：玉米黄素与温度呈显著正相关，与盐度呈显著负相关；19‘-丁酰基氧化岩藻黄素与温度呈显著负相关，与盐度呈显著正相关；二乙烯基叶绿素 *a* 与温度呈显著正相关，与盐度呈显著负相关，与营养盐呈负相关。

南海春夏两季浮游植物生物量和群落结构的比较：除近岸的岩藻黄素和玉米黄素以夏季高于春季外，调查的绝大部分区域主要特征光合色素浓度均呈春季高于夏季。两个季节海盆区的群落结构的垂直分布相近，贫营养的表层和 25 m 以聚球藻占绝对优势；75 m 至 150 m 以定鞭金藻 4 型占优势；DCM 层的优势类群为定鞭金藻 4 型、聚球藻和原绿球藻。

南海浮游植物生物量和群落结构对上升流和中尺度涡的响应：春季南海西

部上升流抬升了叶绿素最大层深度，增加了水柱总 Chl *a* 浓度和硅藻与青绿藻比例。在夏季南海西南部受中尺度涡影响的海域，优势类群为定鞭金藻、聚球藻和原绿球藻。中尺度涡影响了总 Chl *a* 的垂直分布，如暖涡加深了叶绿素最大层。中尺度涡改变了群落结构，暖涡区定鞭金藻贡献量增加，而原绿球藻和聚球藻贡献量降低；冷涡区聚球藻贡献量减少，硅藻贡献量增加。

关键词：浮游植物群落结构；总叶绿素 *a*；光合色素；南海；季节变化

Abstract

In this thesis, spatial and temporal variations of phytoplankton Chl *a* biomass and community structure were studied during spring, 2010 and summer, 2011 in South China Sea (SCS). Phytoplankton photosynthetic pigments were quantified using high-performance liquid chromatography (HPLC), and CHEMTAX program was applied to estimate the contribution of the phytoplankton groups to total chlorophyll *a*. The results show as follows:

The spatial variation of the phytoplankton photosynthetic pigments and composition: During spring, the mean concentration of total integrated Chl *a* over the upper 150 m was 480.45±274.77 ng/L in coast, 261.34±89.55 ng/L in shelf, 204.41±47.20 ng/L in slope and 180.73±41.56 ng/L in basin, respectively. During summer, the mean concentration of total integrated Chl *a* over the upper 150 m was 339.41±124.60 ng/L in coast, 111.48±64.03 ng/L in shelf, 56.42±22.54 ng/L in slope and 82.69±25.83 ng/L in basin, respectively. The concentrations of major diagnostic pigments were different among regions. During spring, major diagnostic pigments were fucoxanthin, zeaxanthin and Chlorophyll *b* in coast; Chlorophyll *b*, dinivyl chlorophyll *a* and 19'-hexanoyloxyfucoxanthin in shelf; while dinivyl chlorophyll *a*, 19'-hexanoyloxyfucoxanthin and zeaxanthin in slope and basin. During summer, major diagnostic pigments were fucoxanthin, zeaxanthin and Chlorophyll *b* in coast; zeaxanthin, dinivyl chlorophyll *a* and19'-hexanoyloxyfucoxanthin in the shelf, slope and basin. Calculations by CHEMTAX showed that during spring *Synechococcus,* followed by Diatoms, was most abundant in the coastal water,; Haptophytes type 4 was most abundant, followed by Prasinophytes and *Synechococcus*, in shelf; while Haptophytes type 4, followed by *Synechococcus* and *Prochlorococcus*, was most abundant in slope and basin. During summer, *Synechococcus* and Diatoms contributed the two most portion of the integrated total chlorophyll *a* in coast; Haptophytes type 4, *Synechococcus* and *Prochlorococcus* comprised the major portion of the integrated total chlorophyll *a* in the shelf, slope and basin. The correlationships between major diagnostic pigments and environmental factors revealed that zeaxanthin positively

correlated with temperature and negatively correlated with salinity; 19'-butanoyloxyfucoxanthin negatively correlated with temperature and positively correlated with salinity; divinyl cholorophyll a positively correlated with temperature but negatively correlated with salinity and nutrients.

The comparison of the phytoplankton biomass and community structure between spring and summer in SCS: The concentrations of major diagnostic pigments were higher during spring than summer, except that the concentrations of fucoxanthin and zeaxanthin were higher during summer than spring in the coast. The vertical distributions patterns of community structure during two seasons were similar in basin. *Synechococcus* were predominant in the oligotrophic surface and 25 m layer waters; while Haptophytes type 4 dominated from 75 m to 150 m; at the depth of chlorophyll maximum, phytoplankton community was characterized by high contribution of Haptophytes type 4 followed by *Prochlorococcus* and *Synechococcus*.

Response of phytoplankton biomass and community structure to upwelling and mesoscale eddies: During spring, the upwelling in western SCS elevated the depth of chlorophyll maximum; increased the concentration of integrated total chlorophyll *a*; and increased the proportions of Diatoms and Prasinophtes. During summer in the region influenced by mesoscale eddies in southwestern SCS, the dominant groups were Haptophytes, *Synechococcus* and *Prochlorococcus*. Mesoscale eddies influenced the vertical distribution of total Chlorophyll *a*, like deepening the depth of chlorophyll maximum in warm eddy. Mesoscale eddies changed the community structure in warm eddy where the contribution of Haptophytes increased but the *Synechococcus* and *Prochlorococcus* decreased and cold eddy where the contribution of *Synechococcus* decreased but Diatoms increased.

Key words: Phytoplankton community structure; Total Chlorophyll *a*; Photosynthetic pigments; South China Sea; Seasonal variation.

缩略语中英文对照表

缩略词	英文全称	中文全名
19BUT	19’-butanoyloxyfucoxanthin	19’-丁酰基氧化岩藻黄素
19HEX	19’-hexanoyloxyfucoxanthin	19’-己酰基氧化岩藻黄素
ALLO	Alloxanthin	别藻黄素
Chl *a*	Chlorophyll *a*	叶绿素 *a*
Chl *b*	Chlorophyll *b*	叶绿素 *b*
Chl *c*1	Chlorophyll *c*1	叶绿素 *c*1
Chl *c*2	Chlorophyll *c*2	叶绿素 *c*2
Chl *c*3	Chlorophyll *c*3	叶绿素 *c*3
CHLO	Chlorophytes	绿藻
CRYPT	Cryptophytes	隐藻
DCML	Deep Chlorophyll a Maximum Layer	叶绿素最大层
DIAD	Diadinoxanthin	硅甲藻黄素
DIATX	Diatoxanthin	硅藻黄素
DIAT	Diatoms	硅藻
DINO	Dinoflagellates	甲藻
DMF	N,N-dimethylformamide	二甲基酰胺
DV-Chl*a*	Dinivyl chlorophyll *a*	二乙烯基叶绿素 *a*
DV-Chl*b*	Dinivyl chlorophyll *b*	二乙烯基叶绿素 *b*
FUCO	fucoxanthin	岩藻黄素
HPLC	High Performance Liquid Chromatography	高效液相色谱
HAPT3	Haptophytes type 3	定鞭金藻 3 型
HAPT4	Haptophytes type 4	定鞭金藻 4 型
	Lutein	叶黄素
NEO	Neoxanthin	新黄素
NO_3	Nitrate	硝酸盐
PERI	Peridinin	多甲藻素
PO_4	Phosphate	磷酸盐
PRASX	Prasinoxanthin	青绿藻素
PRAS	Prasinophytes	青绿藻
PRO	*Prochlorococcus*	原绿球藻
SiO_3	Silicate	硅酸盐
SYNE	*Synechococcus*	聚球藻
t_R	Retention time	保留时间
T Chl*a*	Total Chlorophyll *a*	总叶绿素 *a*
	α-carotene	α-胡萝卜素
	β-carotene	β-胡萝卜素
VIOLA	Violaxanthin	堇菜黄素
ZEA	Zeaxanthin	玉米黄素